GEM-SHINE-CEDAR Workshop Summary

- Dave Webb: Summary of solar and solar wind characteristics of events
  - May 97: Small flare and dissapearing filament in an active region followed by a long-lived coronal arcade. Typical solar wind speed ... cloud got to Earth in 80 hrs. Magnetic flux rope with S-N field rotation, duration of >29 hrs, and axis in the ecliptic plane
  - September 98: Flare and CME associated with disappearing filament. Fast solar wind -- magnetic cloud got to Earth in 50 hrs.
  - October 98: Halo CME associated with a disappearing filament, No flare-- slow in getting to Earth ... over 100 hrs, IMC observed with S-N field rotation and duration of 26 hrs. Axis of IMC tilted out of ecliptic plane

- Sara Martin:
  - Filament sits above a neutral line -- all ejecta, solar flares, etc. are keyed to polarity inversions -- any filament can erupt to give a mass ejection
  - All filaments have magnetic twists or handedness (discovered about 7 yrs ago)
  - can predict handedness -- cleanest information comes from high resolution H alpha images
  - enough information exists for all 3 events to determine handedness of filaments that generated clouds
- Vic Pizzo:
  - Models of the solar wind can reasonably produce the quiet solar wind structures & hypothetical CMEs but there are not sufficient observations to model CME events realistically. STEREO should produce breakthroughs in this capability

- Joan Feynman: Dst is not a good proxy for the higher energy particles that actually cause problems
  - Solar energetic particle events > 1 MeV called SEPs are the dominant influence on spacecraft outside of the radiation belts (over poles, interplanetary space, Mars, solar vicinity). Most hazardous ones at Earth are >10 MeV
  - In intense events, shock acceleration is important -- shock is most efficient in accelerating particles to 10's of MeV near the sun but can accelerate particles to hundreds of MeV
  - SEP can go on for many days. Some problems in spacecraft systems can be due to the peak flux, some due to the integral flux

- Janet Luhmann: Cannot study storms without understanding the time-series of IMF and solar wind parameters. --- highly driven
  - Order of structures is very important
    - Oct 18 1998 had a trailing high speed stream, speed much faster than ICME itself -- might be similar to Jan 10 1997
    - Other 2 CMEs have different pattern in velocity -- combining southward field with high velocities -- velocities peaked early in the event.
    - High density and high helium content in filament material can cause increased dynamic pressure. Helium is a good tracer of filament material in IPM
  - Major coupling questions:
    - How important are conditions before the ICME?
    - What are the specific effects of the shock/sheath related magnetospheric compression?
    - What are the specific effects of the cloud or ejecta?
    - How important is the cloud polarity?
    - How important is the presence of filament/prominence material? .... of a trailing high speed stream?

- Thomas Zurbuchen : Use composition of solar wind as a tracer for timing studies of entry into the magnetosphere and to identify solar sources. Basically there are two states of solar wind: fast wind from coronal holes, and slow wind from current sheets/ streamers. Ejecta (CMEs) have unusual states.
  - O7+/O6+ anticorrelated to velocity. Good measure of electron temperature very close to the sun. Coronal holes are cold. High O7+/O6+ in magnetic clouds. Low average charge states of Fe in coronal holes; high in magnetic clouds.
  - Mg/O ion ratio varies according to solar origin -- enhancement occurs in closed magnetic structures -- good way of tracing matter down and determining whether it occurs in closed magnetic structures.
  - Composition helps sort out the origin of solar wind structures
  - If Fe and heavy ions occur in the solar wind, enhanced dynamic pressure will occur (in April-May 98, Fe produced 20% effect, helium about 50% effect on dynamic pressure)
  - Abrupt changes in solar wind charge states provide tracers for entry, transport, energization of SW ions into magnetosphere

- Ted Fritz: See many cases of energetic ions in the cusp region. 800 examples of velocity dispersed signatures over a 2 year period from Polar -- peak on afternoon side. Need to understand mechanisms for transport and acceleration of energetic ions
- Dan Baker: Electron radiation belts
  - May 97: rapid radiation belt enhancement at L=3-4 right near time of min Dst (shortly after shock). Enhanced ULF wave activity both in the ground & space. Believe substorm activity produced seed population processed by ULF waves & other drivers to enhance belts
  - September 98 -- modest event, October 98 weak event -- Need to understand why this is true
    - Sept 98: solar wind speed decreased after a short time -- need extended period of high speed wind to get enhancements
    - Oct 98 -- relatively short period of high energy input -- wind speed relatively low -- not effective in enhancing the belts

- Joe Borovsky (presented by Janet Kozyra): Good correlation between peaks in solar wind density (Nsw) and peaks in plasma sheet density (Nps) at geosynchronous orbit with some time delay
  - May 97: plasmasheet density increased from 0.5/cc to ~2.5 /cc during main phase, Nsw reached ~55/cc.
  - Sept 98: Nps increased to ~2.5 /cc, Nsw peaked near 20/cc
  - Oct 98: Nps enhanced to almost 6 /cc, Nsw peaked near 80/cc
- Michelle Thomsen (presented by Janet Kozyra): Upflowing O+ seen at geosynchronous orbit during Oct 98 storm
    - During high solar wind dynamic pressure interval, magnetosheath plasma was observed at geosynchronous orbit.
    - After the abrupt termination of the high pressure, the LANL s/c re-entered the magnetosphere and became immersed in a region of upflowing ions.
    - There was a energy dispersed signature which appear to be O+ from time-of-flight calculations

- Mike Liemohn (presented by Janet Kozyra): Magnetopause compressions examined with Shue et al [1998] model -- all predicted magnetopause compressions by this model were observed by the LANL geosynch spacecraft -- compressions are important for ring current and radiation belt loss, and have been correlated with the appearance of upflowing O+ ions.
  - May 97: ~ hour long compression of the magnetopause inside geosynch orbit during the main phase
  - Sept 98: 2 ~ hour-long intervals early on the 25th during the main phase
  - Oct 98: 1 very brief and 1 several hour-long compression inside geosynch.

- Bill Peterson : Energization and escape of O+ -> focus on Joule heating and centrifugal acceleration effects
  - Joule heating -- can only drive O+ up to about 2000 km by itself
    - O+ fluxes observed on Dynamics Explorer (DE-1) were inconsistent with those modeled using DE-2 observations unless there was acceleration above 1500 km.
  - Centrifugal acceleration --
    - ions can acquire energy parallel to the magnetic field. This energy is proportional both to the drift velocity and to the rate of change of the magnetic field seen by the ion as it moves along the magnetic field line
    - implies energy is transferred in regions where there is a significant rate of change of magnetic fields such as during storm sudden commencements (SSCs)
    - Not previously appreciated as an important process until Sept 98 event. Magnetic field rotated 20 degrees when the shock hit. The rate of change of B in response to the SSC produces an intensificaton of the ion fluxes

- Bill Peterson (cont'd): Major questions related to outflowing O+
  - Where do the enhanced O+ outflows in the cusp associated with the SSC go? .... out the tail as seen by Geotail? ... into the plasma sheet? What are the mechanisms associated with the SSC that give the extra acceleration to the outflowing O+?
  - Can we model the resulting composition changes in the magnetotail and confirm them with observations of precipitating plasma sheet fluxes?
- Damien Chua: POLAR/UVI auroral observations
  - dayside enhancements of auroral emissions were associated with the arrival of the pressure pulse (fairly uniform increase in emissions from 9-15 MLT)
  - dawn-dusk asymmetry in auroral response (intensification propagates asymmetrically across dawn to the nightside)
  - delay between dayside & nightside auroral intensification after arrival of ICME was very short (~1min)
  - Intensity of auroral emissions indicates a characteristic exponential decay time in auroral power input of 22 min

- Damien Chua (cont’d): Science issues associated with POLAR/UVI auroral emissions
  - What is physical significance of the exponential decay of the energy deposition
    - What parameters in the magnetosphere or in the ICME determine the decay time?
  - What mechanisms account for the auroral response to the ICME? Why is it correlated with pressure pulses?

- Gang Lu: Energy deposition in the auroral ionosphere
  - 15 May 97: Showed plots of AMIE-derived parameters. In summary, polar cap potential drop in the northern hemisphere reached 150 kV, joule heating up to 700 GW, auroral energy flux peaking at 170 GW, more usually ~120 GW
  - 25 Sept 98: potential drop up to 200 kV, Joule heating peaking at 1700 GW, more usually ~700 GW, auroral energy flux peaking at 250 GW, more usually 200 GW

- John Sigwarth (presented by Janet Kozyra): POLAR/VIS observations for May 97 and September 98. Summary plots available at http://www-pi.physics.uiowa.edu/~sigwarth/gem1999/
  - May 97:
    - Initial phases of storm, auroras dominated by dayside brightening in the cusp/cleft region
    - Main phase -- auroral oval thinned and polar cap area increased -- dominated by strong auroral activity.
    - Recovery phase -- aurora gradually less active
  - Sept 98:
    - Initial phase -- auroras dominated by dayside brightening in the cusp/cleft region During first 30 min of the dynamic pressure impulse, entire oval became active and polar cap shrank to less than 1/2 of its size (new mode of magnetospheric response not previously appreciated)
    - Main phase: auroral oval moved equatorward, became thin and polar cap area increased by factor of 3. Discrete substorms at 0142 UT and 0427 UT but signatures nearly overwhelmed by continuous strong activity.

- Mike Ruohoniemi: Superdarn radars operated continuously at 2 min time resolution
  - posted summary plots for the campaign storm intervals on web site <http://superdarn.jhuapl.edu/> -- not completely verified yet -- contact PIs for useage
- John Foster: Ionospheric observations
  - On average, get twin-peaked convection in the dusk sector. Equatorward peak due to ring current shielding effects
  - Difference between September 98 and October 98 observations -- September has a tremendous twin-peaked convection electric field structure -- Oct 98 does not. Oct 98 looks like a succession of substorms, rather than the convection pattern from an intense magnetic storm.
  - Radar in Irkusk, sitting under subauroral ion drift (SAID) event for long period during Sept 98. Observed > 100 mV/m electric fields.